Water Sampling with a SeaPerch ROV: The Fen-Tastic Four

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Project Overview

Water sampling is important when monitoring the water quality of an area. Normally water bodies are sampled from above using a hanging Van Dorn bottle (standard equipment used in lake studies to capture water samples at various depths from above the sampling location).

However there are areas where humans are unable to easily reach such as an underwater cave or under the mat of a fen or bog. A purposely engineered Seaperch ROV (Remotely Operated Vehicle) can provide the perfect tool to collect water samples from these hard to reach places with minimal environmental impact.

Upon designing several sampling methods compatible with a Seaperch ROV the engineers concluded that two of their water collecting device designs, one remotely operated and one surface operated, are best suited for collecting water samples in difficult to reach aquatic environments.

The remotely operated design, referred to as the Widget Ball Model, captures water by releasing tension to snap widget balls to close an open tube. The surface model, known as the Siphon Model, consists of a flexible narrow tube, in this case a fish tank air hose, that leads from the surface to the ROV. A researcher at the surface uses a syringe to extract water through the tube from the location of the ROV to collect a sample.

Background & Rationale

The project idea developed from some of the studies done last year in biology class working with Cathance River Education Alliance (CREA). At the Cathance River Preserve, Topsham, Maine there is a fen. Much of its surface is covered with a mossy mat, making it hard for people to explore below the surface without disturbing the ecosystem.

The goal of this project is to design a method to collect a water sample below the marshy mat without disrupting the ecosystem. These areas are home to many living organisms, and studying their home could put their ecosystem off balance and disrupt them. By collecting water samples beneath the mossy mat, further tests can be run and new data can be collected to better understand these ecosystems. Later the findings can inform the public how to further protect and support them.

Basic Background Information

- Fen: A low, marshy area that is, in many cases, frequently flooded.
- Van Dorn Bottle sampler: standard equipment used in lake studies to capture water samples at various depths from above the sampling location.
- Buoyancy: the tendency of an object to float when submerged in a liquid.
- Neutral Buoyancy: Occurs when the average density of an object is equal to the density of the liquid around it, resulting in the buoyant force balancing the force of gravity, allowing the object to appear to "hover" in the liquid.
- Worm Gear: A cylindrical gear consisting of a spiral thread. This allows an attached gear to rotate perpendicular to the worm gear. In the case of this ROV, it rotates, releasing the hooks that keep the widget balls from closing the container.

Background Images

Van Dorn bottle borrowed from Stantec (environmental consulting company).

Hudson holding the Van Dorn sampler.

Example of a Fen

Worm Gear

Approach

ROV chassis approach:
- Small, with no rough edges that it could get stuck on
- Neutrally buoyant to aid control
- The Widget Ball Model should be placed more in the front to counter the weight of rear motors.

General water model design approach:
- Minimal effect on buoyancy
- Minimal effect on the control of ROV
- Watertight and reliable
- Many concepts were considered, three were made (Widget Ball, Siphon, and Balloon Models), of these two were determined effective.

Widget Ball Model approach:
- Triggered by a motor
- Minimize gear friction
- This model could reliably capture a water sample without leaks, but it required the ROV to surface.

Siphon Model approach:
- Flexible tube affixed to the cable to prevent it from getting stuck
- Inexpensive, but reliable pump for water
- This model could easily and reliably collect a water sample without requiring the ROV to surface.

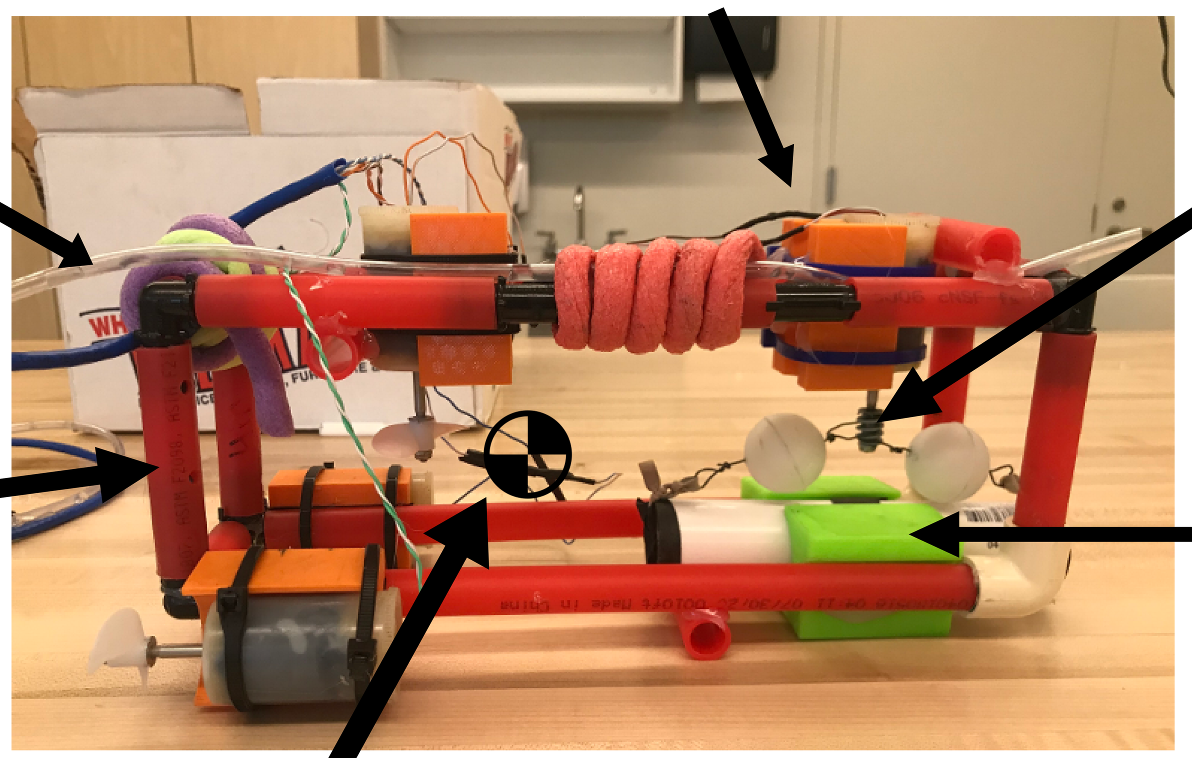
Balloon Model approach:
- Flexible tube affixed to the cable to prevent it from getting stuck
- Inexpensive, but reliable pump for air
- Smooth edges to prevent the balloons from popping
- The design was not reliable enough to go any further than testing, the balloons were prone to popping.
- After the balloons were filled and the hose was sealed, air would still leak, indicating that it could not contain a water sample.

ROV Design Features

4th Motor:
Trips the Widget Ball Model by spinning the attached worm gear.

Siphon Model:
To prevent the Siphon Model's hose from getting caught, it was attached to the blue electrical cable using electrical tape.

1/2 inch PEX Pipe,
This material is smaller and lighter than PVC, while still maintaining its rigidity and strength.



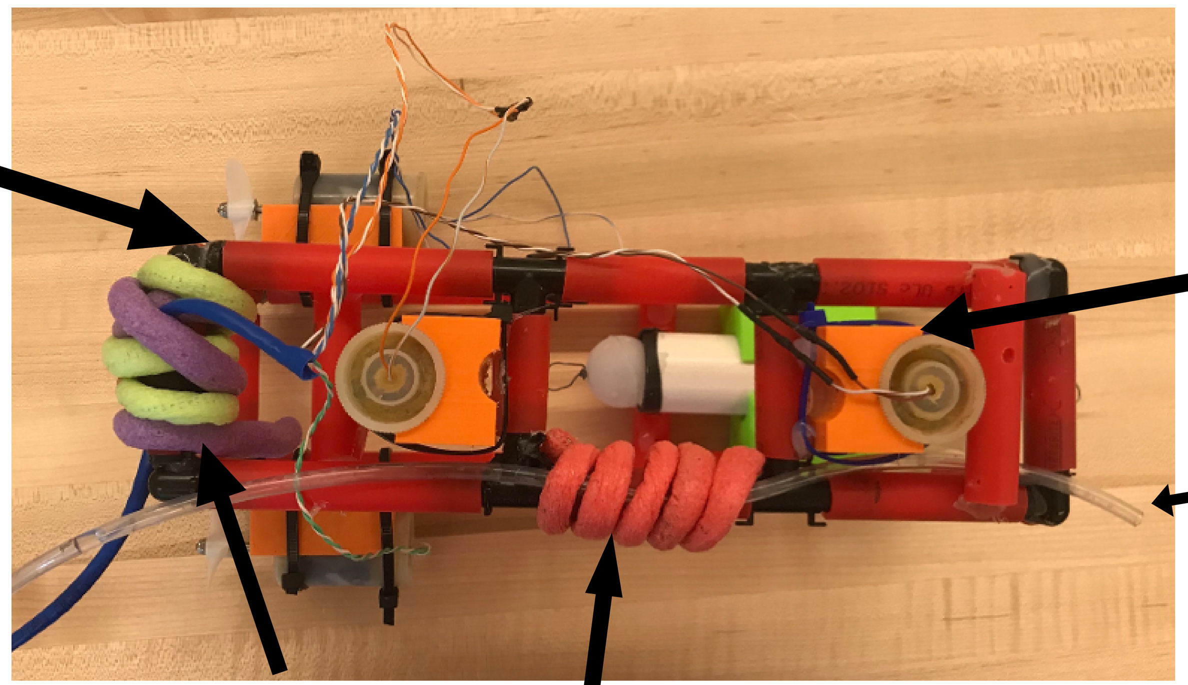
Worm gear:
The worm gear is connected to the 4th motor. When rotated by the motor it frees the widget balls, which are then pulled to close the sampling tube with a rubber band, capturing the water sample.

Widget Ball Model:
- Removable water sampler.
- Left open to allow water flow, so that the sample doesn't get contaminated.
- The black on the edges of the PVC is rubber tape, put in place to make a watertight seal.
- The Widget Ball Model is held onto the ROV with two bright green 3D printed holders, which clasp around the tube holding it in place with the assistance of rubber tape, to increase the friction.

Center of Mass:
This is roughly the center of mass of the ROV.

Self-Righting
To allow the ROV to be self-righting, the center of mass needed to be directly below the center of buoyancy when the ROV is level.

Chassis:
The ROV was purposefully designed to be narrow as shown here, allowing access to tight spots.



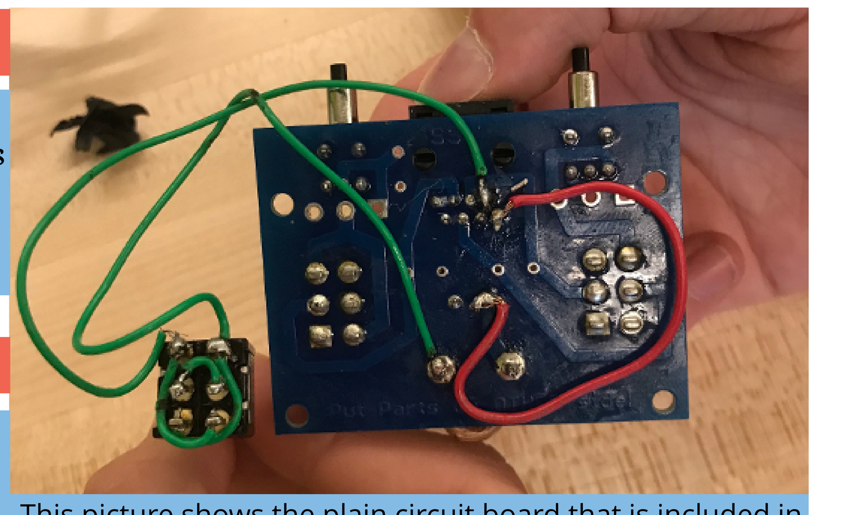
Motor Mounts:
The bright orange parts of the ROV are the motor mounts, which were custom designs and 3D printed specifically to keep the motor positions secure.

Siphon Model:
This is the end of the Siphon Model's tube where the water sample is collected. To collect the water sample, the syringe at the other end of the hose must be drawn.

Flotation:
Helps keep the ROV neutrally buoyant.

Approach: The Fourth Switch

Since a fourth motor was needed for the some of the designs, the first issue was determining how to wire the fourth switch to operate the fourth motor.



This picture shows the plain circuit board that is included in the SeaPerch starter kit, with a fourth switch attached, to activate the water collection device. The top green wire is attaching the fourth switch to the fourth motor while the bottom green wire attaches the switch to the power source. The red wire links the fourth motor to the fuse.

Approach: Wiring

Since there were no guides on how to wire the fourth motor, a few hours were spent just testing where to attach the wires.

Ultimately, some assistance from Robonation was needed to show where to attach the wires.

Discussion & Reasoning

After testing three different water sampling methods it was found that both the Widget Ball and the Siphon Models were best able to collect water samples. The Widget Ball Model held a secure supply of water when tested for leaks (pH tests). The Siphon Model could effectively and efficiently get an unlimited water sample to the surface, with the main concern that all connections be water-tight

Surprises:
- How difficult it was determine how to wire the fourth switch to the control box.
- How much friction affected the water samplers from functioning properly.

Lessons :
- Throughout this process everyone gained an appreciation for what engineers go through.
- There is an immense amount of effort to design and build one solution that works reliably well.

Conclusions & Next Steps

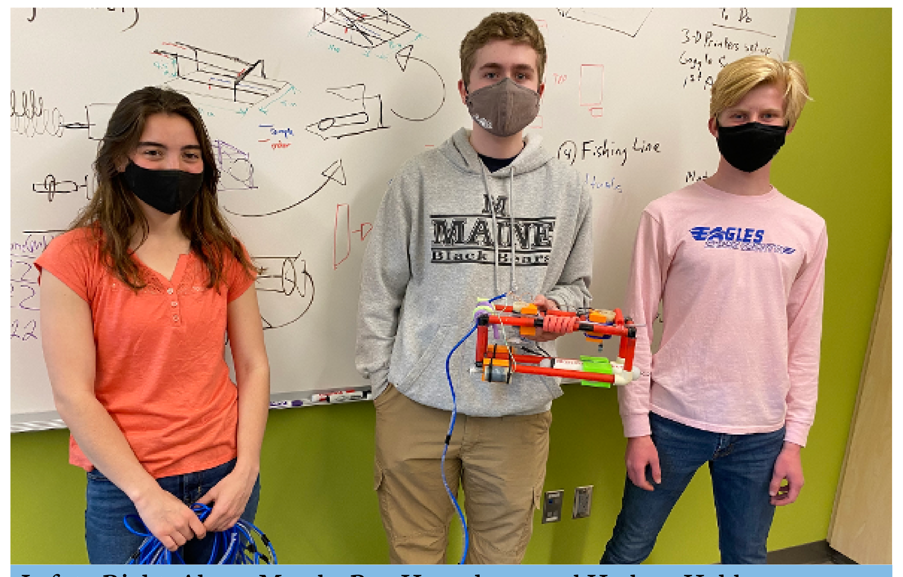
CONCLUSIONS:

Ultimately both the Siphon Model and the Widget Ball Model were able to collect a water sample when attached to the ROV. Both sampling methods have their pros and cons. The Siphon Model can provide unlimited samples from the area. However, the small tube opening limits the size of particles collected. The Widget Ball Model is an effective innovative way to collect a smaller water sample containing larger particles. Improvements can be made to make this model more reliable.

The Balloon Model was definitely flawed and didn't work as planned. There was too many issues with air and water leakage when using this design. The balloons sometimes broke.

The models that weren't made due to limited time still have potential. These other models are further elaborated in the Technical Design Report.

NEXT STEPS:
- Camera or depth monitor to make ROV movement easier for the operator. This will also allow visual information to be collected under the fen mat.
- The several water sample models that weren't built ultimately could be built and tested. Of those samplers the Totally Tubular idea was most promising. The friction and leakage should be minimal. It can easily be modified to make it bigger .
- The engineers plan to share the ROV and the newly designed sampling techniques with Stantec (local environmental consulting company).



Left to Right: Alyssa Moody, Ben Humphrey, and Hudson Holden, presenting the final design of their ROV.

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